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(54) Tundish with gas injection tile

(57) A tundish used in a steel making process includes a replaceable refractory lining (16) disposed on the inner surface of the bottom and side walls of the tundish. A porous refractory tile (18) is supported upon the upper surface of the refractory lining and has a major axis extending substantially the entire width of the tundish. The tile encapsulates a conduit (22) extending parallel to the major axis. The conduit is in fluid flow communication with a source of inert gas. The conduit has a plurality of exit openings (23) for delivering inert gas into the core of the tile. The tile includes a ramp-like surface (20) for deflecting steel flowing theretowards upwardly within the tundish. The exit openings of the conduit direct the inert gas emanating therefrom upwardly through the porous tile to form a layer of inert gas across the width of the tundish, and extending above the upper surface of the tile.

The tundish also includes an impact pad (30) upstream of the ramp-like surface (20). A damming effect of the tile creates a molten metal pool overlying the impact pad, and thus reduces erosion of the tundish lining.

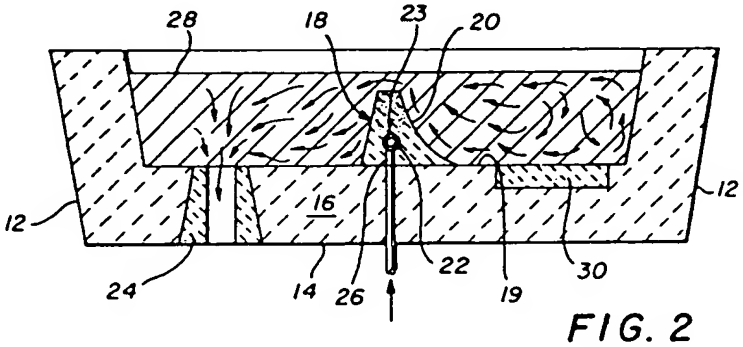


FIG. 2

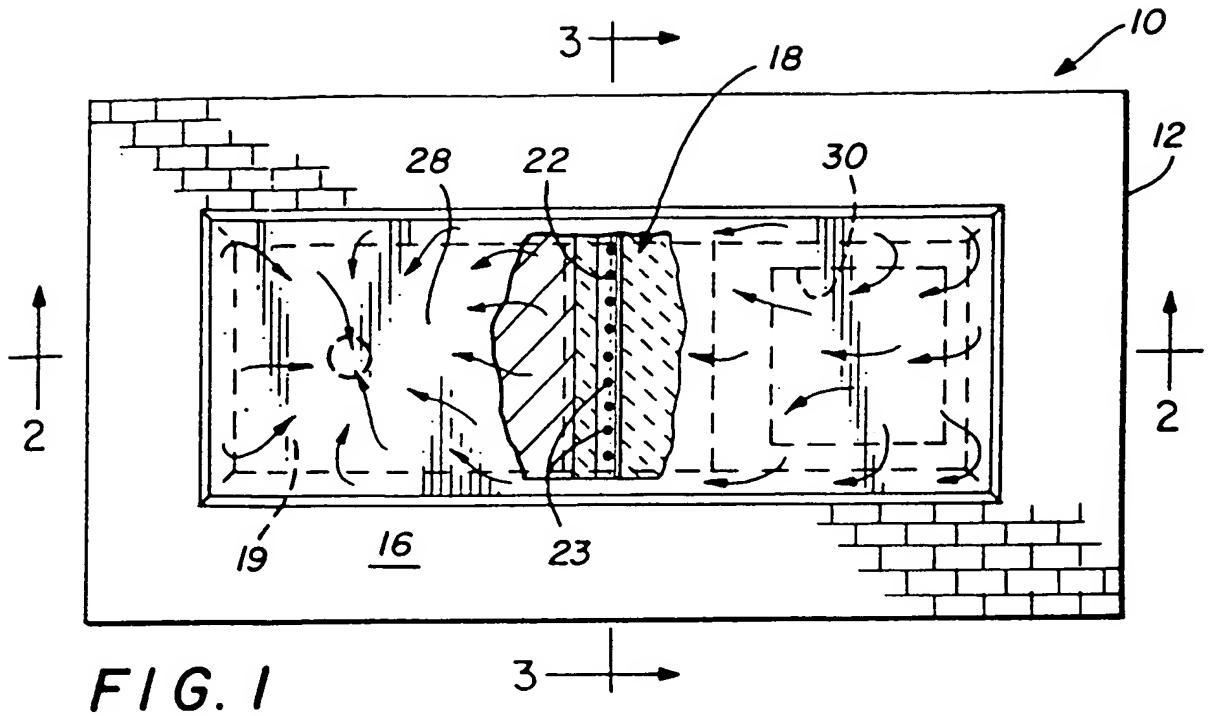


FIG. 1

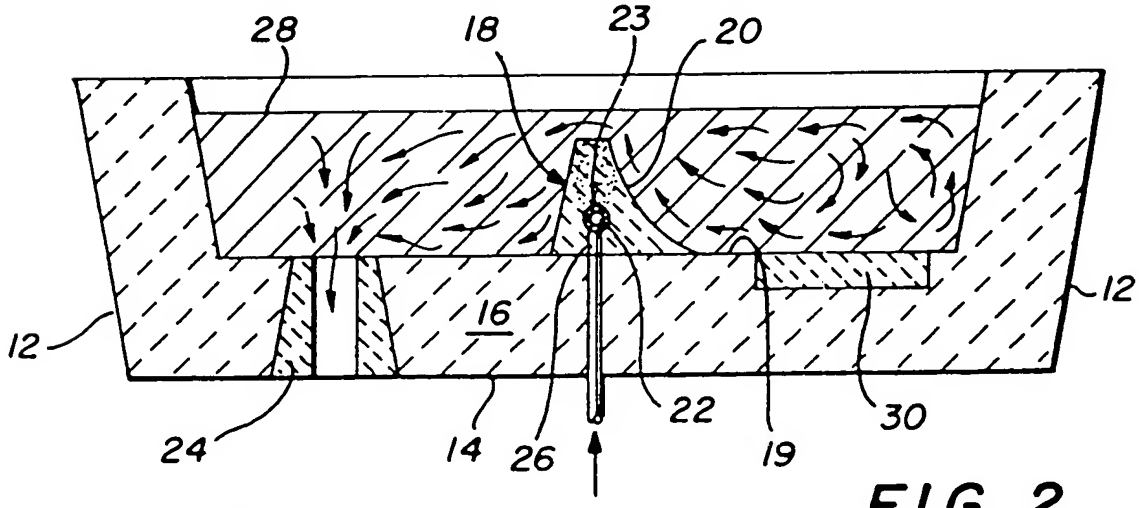
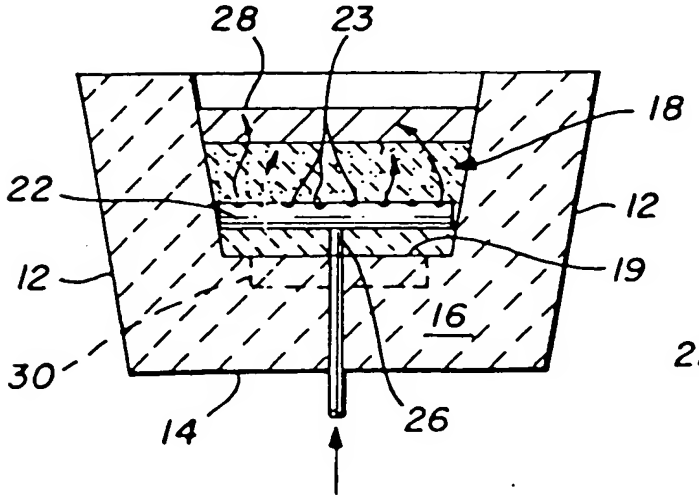


FIG. 2



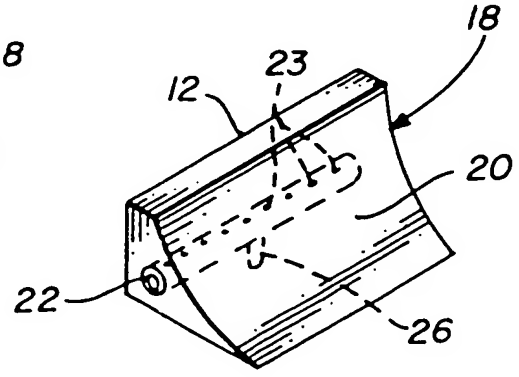


FIG. 4

SPECIFICATION

Tundish with gas injection tile

The present invention relates to a tundish and in particular, to a tundish having refractory tile for separating inclusions from the molten steel.

During the steel making process, minute refractory grains from the erosion of refractory vessel linings and metallic oxides formed by the reaction of the metals in the molten steel with the atmosphere are suspended in the molten steel. The suspended refractory grains and metallic oxides are known as inclusions. The inclusions impart undesirable properties to finished steel. The removal of these inclusions provides a major improvement in the quality of the steel.

Previous attempts to reduce inclusions in steel have included:

1) increasing the volume of the tundish which allows increased holding time for the inclusions to flow naturally to the top of the melt;

2) providing baffles within the tundish to increase the path that the molten steel must travel in passing through the tundish, resulting in increased time for natural flotation of the inclusions;

3) addition of a synthetic slag coating on the top surface of the molten steel with reacts with the inclusions and binds the inclusions with the slag; and

4) injecting an inert gas through porous plugs or nozzles which provides stirring action and added lift towards the top of the molten steel.

Current porous plugs or nozzles are cylindrical or conical resulting in a lifting action confined to the area immediately above the plug or nozzle. These plugs or nozzles are installed as part of the tundish lining and are mounted flush with the bottom of the refractory lining. The plugs or nozzles are protected by a non-porous block resulting in both plug and block becoming a semi-permanent part of the refractory lining. The plugs, blocks and nozzles are semi-permanent due to the duration of their operational life which allows approximately 1 to 5 casts before necessitating replacement. Replacement can only be accomplished by dumping all steel and slag from the vessel, removing the vessel from service, allowing the vessel to cool and manually or mechanically removing the plugs or nozzles using bars and or impact hammers.

The preferred embodiment of the present invention permits an increase in the efficiency of inclusion removal from molten steel. Further, installation time and turn round time in effecting repair or replacing is reduce. The foregoing results in increased productivity. Still further tundish refractory life is prolonged and refractory cost is reduced.

According to one aspect of this present invention there is provided a tundish comprising: a bottom wall; side walls; a replaceable refractory lining placed on the inner surface of the bottom and side walls; and a porous refractory tile supported on the refractory lining and having a major axis extending substantially the entire width of the tundish, the tile having a passage defined therein extending parallel to said major axis, the passage being in fluid flow communication with an inert gas source and including exit means for delivering inert gas into the core of the tile whereby inert gas emanating the passage may flow upwardly through the porous tile to thereby form a layer of inert gas across the width of the tundish extending above the surface of the tile, and the tile including a ramp-like surface for deflecting steel flowing theretowards upwardly within the tundish.

In the preferred embodiment of the invention increased efficiency of inclusion removal is achieved by first deflecting the flow of steel into an upward direction to impart a lift to the molten steel and the inclusion suspended therein. Inert gas is injected through the total length of the invention providing additional lifting action and resulting in an inert gas plane across the full width of the tundish and through the entire cross-sectional area disposed above the invention. Each ounce of molten steel will be deflected upwardly by the invention and will pass through the inert gas plane resulting in more of the suspended inclusion being carried to the surface of the molten steel and absorbed by the slag.

The tile used in the preferred embodiment may be installed with greater simplicity and requires less installation time than plugs or ozzles of the prior art. Installation may be done in a hot tundish without necessitating either manual or mechanical tear out procedures. The foregoing is achieved since the tile is placed on the top of the refractory brick lining rather than within or forming a portion of the lining.

Productivity is increased as fewer tundishes may be required in rotation; reduced turn around time of each tunidish results in greater steel tons per hour, a greater caster machine availabilty and reduced man-hours for tundish maintenance; and reduced demand on crane movements resulted in improved shop logistics.

Tundish refractory life is extended and costs are reduced in the preferred embodiment because the tile serves as a dam resulting in the incoming stream of steel building a pool of steel up-stream of the invention. The molten steel entering the tundish impacts upon the steel pool rather than upon a refractory. Refractory life is further extended since both manual or mechanical impact is reduced, and thermal cycling of the tundish for replacement of the nozzles and plugs is greatly reduced.

Brief description of the drawing

Figure 1 illustrates an elevational view of a tundish including the present invention;

Figure 2 is a sectional view taken along line II-II of Figure 1;

Figure 3 is a sectional view taken along line III-III of Figure 1; and

Figure 4 is a perspective view of a porous refractory tile incorporating the features of the present invention.

Description of the preferred embodiment

Referring now to the various figures of the drawing, there will be described and illustrated a preferred embodiment of the present invention. In refer-

ring to the various figures, like numerals shall refer to like parts.

The present invention is utilized in a tundish used in steel making process. A tundish is a generally large holding vessel used to hold the molten steel during the manufacture thereof. In the preferred embodiment of the present invention, tundish 10 includes side walls 12 and bottom wall 14. A refractory lining 16 for the tundish is provided along the inner surfaces of walls 12 and 14.

A porous refractory tile 18 is installed on the top surface 19 of tundish lining 16. Refractory tile 18 is independent of the tundish lining. In practice, attachment of the tile is made by notches and wedges in the replaceable tundish lining sidewall and bottom wall; the notches and wedges hold refractory tile 18 in place during service. The tile is removed and replaced during the dumping of slag from the tundish as the replaceable side wall lining, bottom lining, and the tile are designed to flow freely from the tundish.

As illustrated specifically in Figures 1 and 4, tile 18 includes a ramp-like surface 20 which faces towards the flow of steel into the tundish. Surface 20 is sloped or curved to impart an upward deflection to the flow pattern of the molten steel. As illustrated in Figure 2, tile 18 extends across the full width of the tundish.

A pipe or conduit 22 is encapsulated in refractory tile 18. The pipe extends parallel to the major axis of tile 18 and thus substantially across the full width of the tundish. Pipe 22 has a plurality of perforations or exit openings 23 provided along its top surface.

As illustrated in Figure 4, pipe 22 is connected to a second pipe 26. Pipe 26 in turn is connected to a source of inert gas (not shown).

An impact pad 30 formed from suitable refractory material, is located in the direct path of flow for the molten steel supplied to the tundish. Tile 18 functions as a dam by, not only directing the molten steel flowing there-towards in an upward direction, but in addition, forming a molten pool of steel upstream thereof essentially on the top surface of pad 30.

Tile 18 is made from highly porous refractory material, resulting in a permeability which provides a flow path for the inert gas exiting from pipe 22. The composition of the tile must provide sufficient refractoriness and strength to protect the pipe and to perform inclusion removal for the duration of the casting sequence. Standard refractory compounds or combinations of alumina, silica, zirconia, zircon, chrome and magnesia are suggested; with magnesia and silicon, favored as the most suitable compounds.

In operation, the molten steel delivered to tundish 10 flows towards ramp-like surface 20 of tile 18. The ramp-like surface deflects the flow of molten steel in an upward direction, thus imparting a lift to the molten steel and the inclusion suspended therein. The inert gas discharged from pipe 22 flows through the porous refractory tile and exits from the top of the tile to form an inert gas plane across the full width of the tundish and through the entire cross-sectional area above the tile. The inert gas curtain thus formed is symbolically represented by reference numeral 28. The entire flow of molten steel is deflected upwardly by ramp-like surface 20 of tile 18. Further, the entire flow of molten steel must pass through the inert gas plane. By imparting the upward flow to the molten steel, and further passing the steel through the inert gas plane, more of the suspended inclusions will be carried to the surface of the steel 28 and be absorbed by the slag.

In addition to the foregoing benefit regarding removal of the inclusions, tundish refractory life is extended and costs reduced because tile 18 serves as a dam resulting in a portion of the incoming stream of molten steel building up a pool of steel on the top surface of impact pad 30. Thus, the entering steel impacts upon the molten pool rather than the refractory impact pad. Thermal cycling of the tundish to replace the impact pad is greatly reduced, thus increasing the service life of the tundish.

While a preferred embodiment of the present invention has been described and illustrated, the invention should not be limited thereto, but may be otherwise embodied within the scope of the following claims.

CLAIMS

1. A tundish comprising: a bottom wall; side walls; a replaceable refractory lining placed on the inner surface of the bottom and side walls; and a porous refractory tile supported on the refractory lining and having a major axis extending substantially the entire width of the tundish, the tile having a passage defined therein extending parallel to said major axis, the passage being in fluid flow communication with an inert gas source and including exit means for delivering inert gas into the core of the tile whereby inert gas emanating the passage may flow upwardly through the porous tile to thereby form a layer of inert gas across the width of the tundish extending above the surface of the tile, and the tile including a ramp-like surface for deflecting steel flowing theretowards upwardly within the tundish.

2. A tundish according to claim 1 wherein the passage is defined by a conduit encapsulated within the tile and the exit means comprises openings in the conduit for directing inert gas upwardly into the porous tile.

3. A porous refractory tile for use in a steel making process the tile having a passage defined therewithin and including a ramp-like surface for deflecting flow of molten steel flowing theretowards in an upward direction.

4. A refractory tile according to claim 3 wherein the passage is defined by a conduit encapsulated within the tile.

5. A refractory tile in acordance with claim 4 wherein said conduit is connected to a source of inert gas and includes plurality of exit means for delivering said inert gas into the core of said porous tile.

6. A tundish for use in a steel making process, said tundish having a bottom wall, side walls, a replaceable refractory lining placed on the inner surface of the bottom and side walls, inlet means for steel delivered to said tundish, a porous refractory

tile supported upon the upper surface of said refractory lining and having a major axis extending substantially the entire width of said tundish, said tile including a ramp-like surface for deflecting steel flowing theretowards upwardly within the tundish, a refractory impact pad supported on the upper surface of said refractory lining upstream of said tile, said tile directing a portion of the molten steel impinging thereon towards the impact pad whereby a pool of molten steel is developed overlying said pad.

7. A tundish in accordance with claim 4, wherein said tile encapsulates a conduit extending parallel to said major axis, with said conduit being in fluid flow communication with a source of inert gas and including a plurality of exit means for delivering inert gas to the core of the tile, the exit means from the conduit directing the inert gas entering therefrom upwardly through the porous tile to form a layer of inert gas across the width of the tundish and extending above the surface of said tile.

8. A tundish substantially as hereinbefore described with reference to the drawing.

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